UNIVERSITY OF ZAGREB
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DEPARTMENT OF ENERGY, POWER AND ENVIRONMENTAL ENGINEERING

An overview of modelling the integration of sectors with a focus on heat supply

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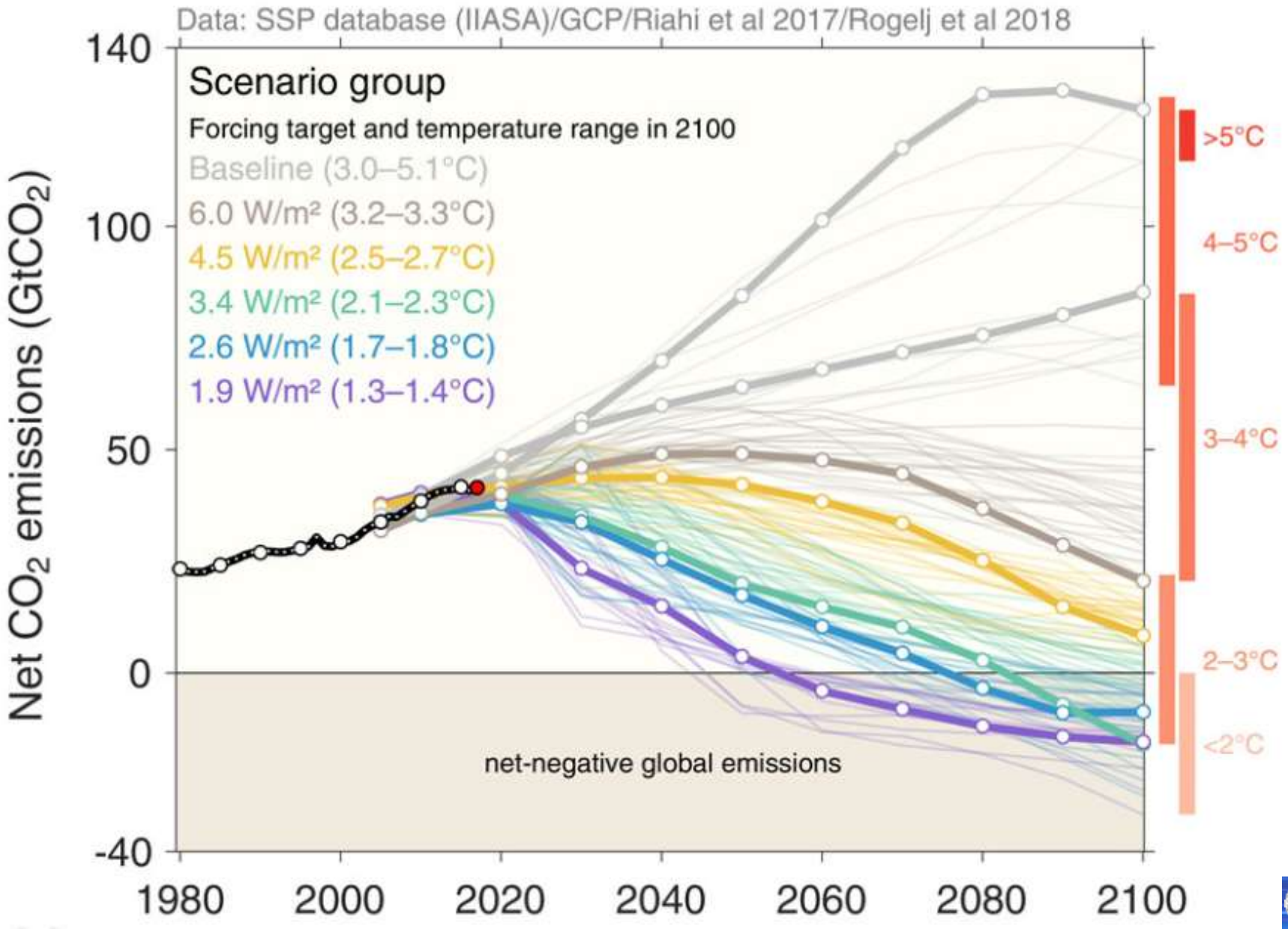
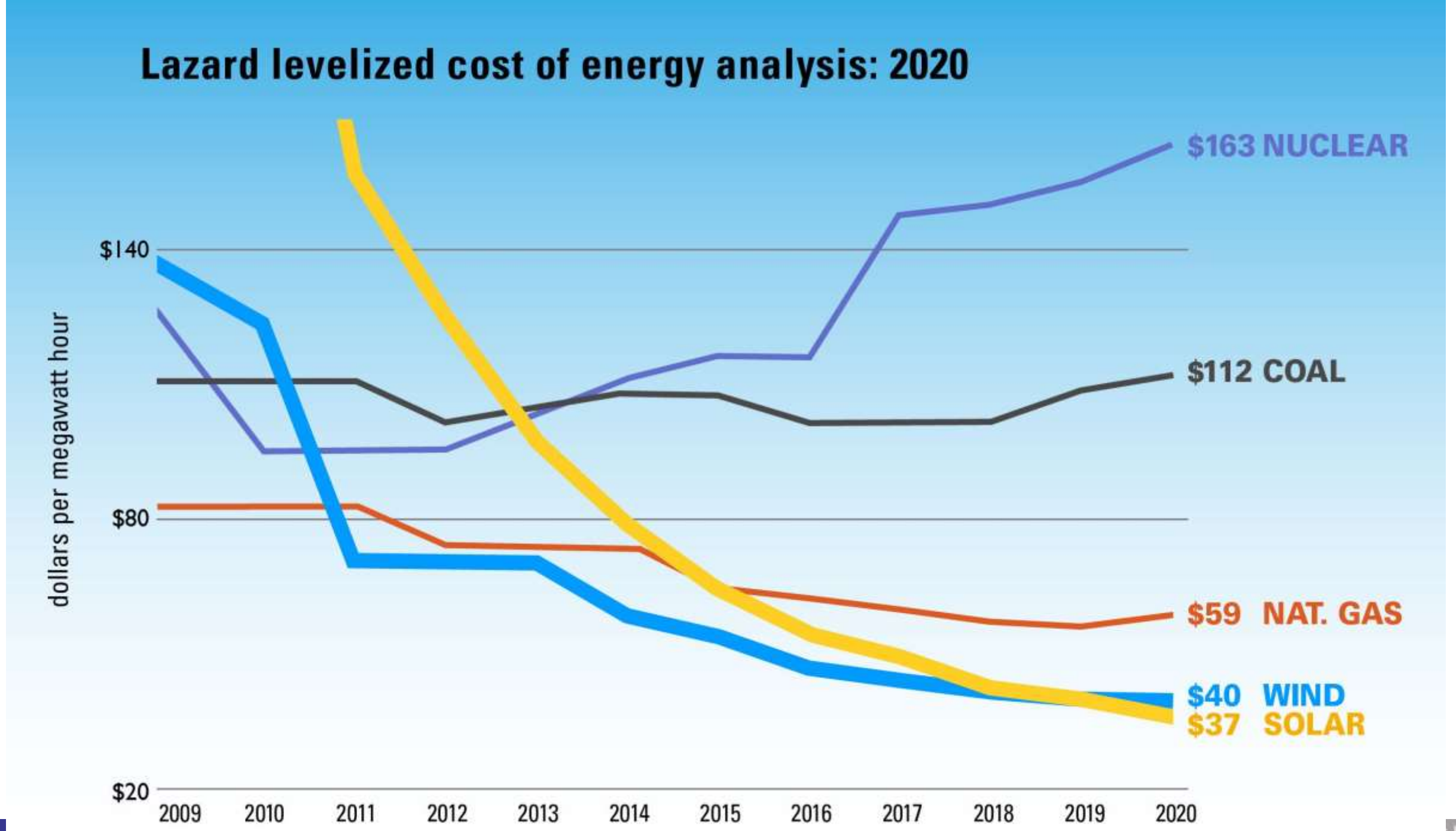
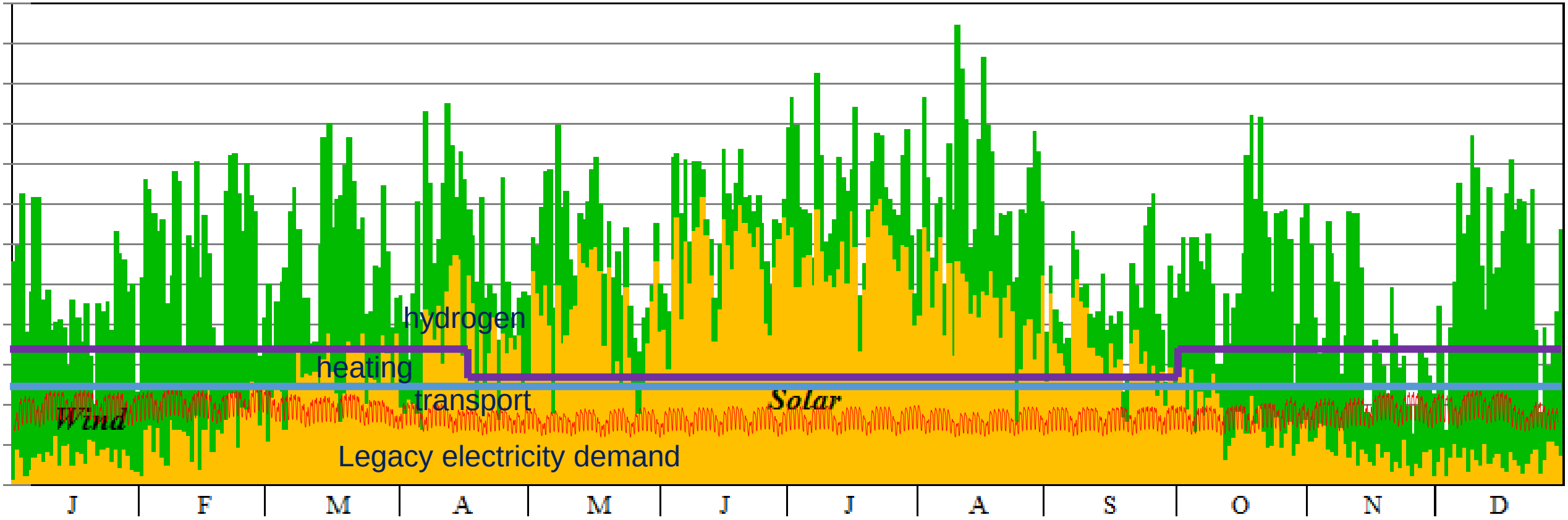
Climate change, just how much?




Lazard levelized cost of energy analysis: 2020
dollars per megawatt hour
$140
$80
$20
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
$163 NUCLEAR
$112 COAL
$59 NAT. GAS
$40 WIND
$37 SOLAR

Wind and solar are actually baseload with excess, which we can use for heating, driving and hydrogen for industry



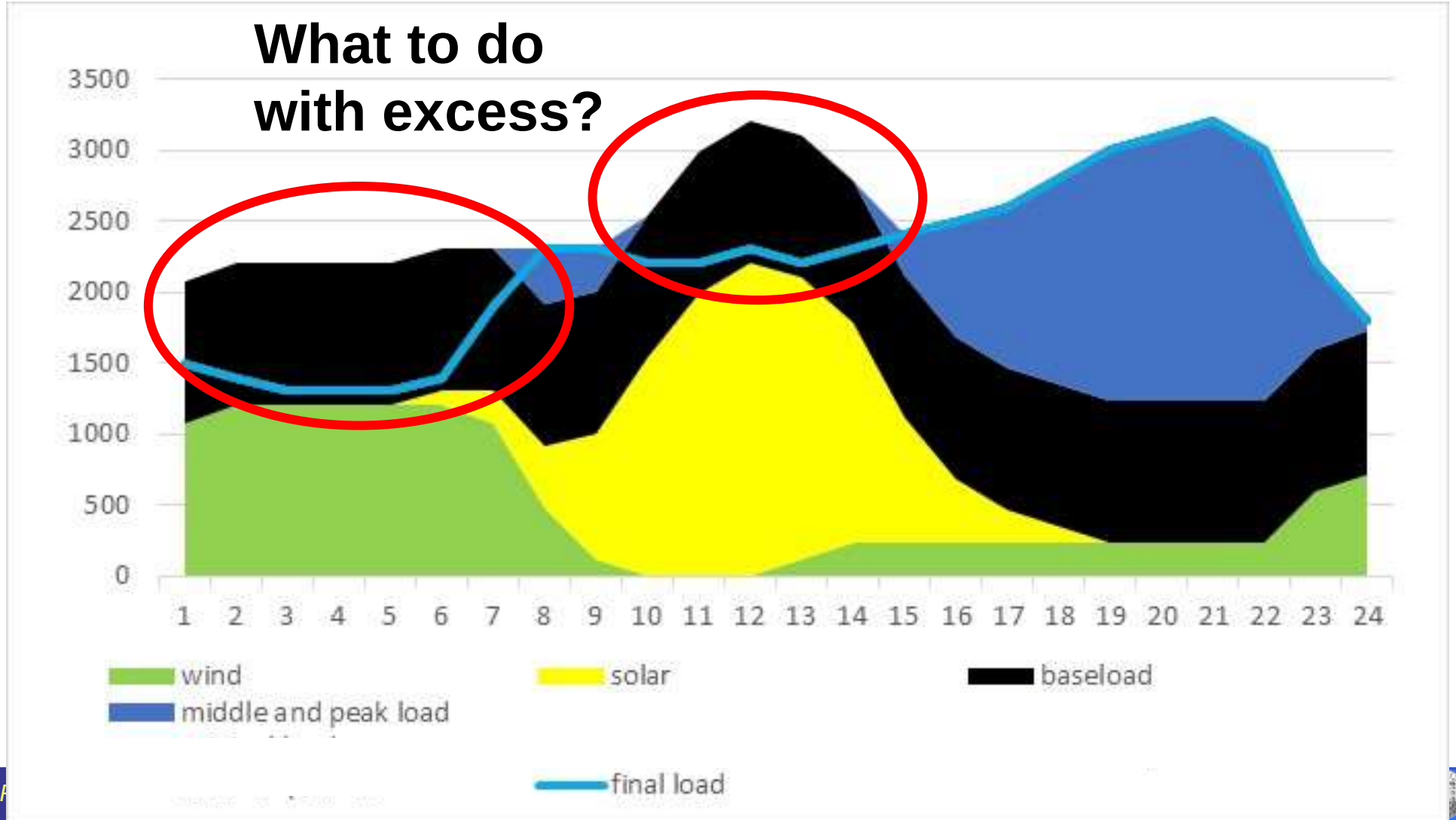
Why IAMs push CCS, which does not happen?

- IAMs cannot model variable sources
- IAMs cannot model system integration
- Simply, IAMs are then wrong, pushing CCS
- Project LOCOMOTION -> WILLIAM will be first IAM to be able to model 100% VRES energy systems

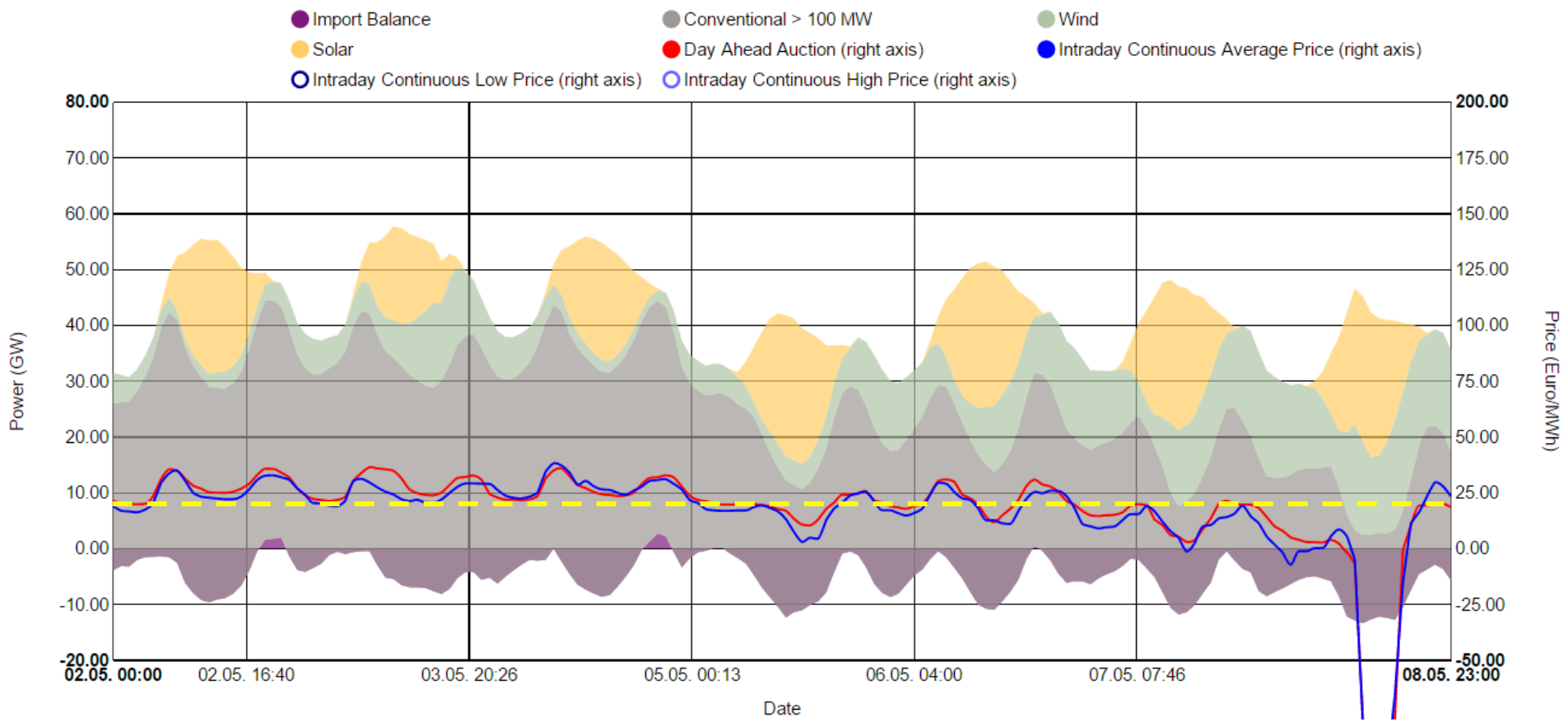
How to solve renewables variability/intermittency problem?

- More grid interconnection
- Flexibilisation of thermal power plants
- Wholesale markets coupling
- Demand response and integration of power, heating, cooling, transport and water systems – power-to-X
- Dedicated electricity storage

Baseload + 25% wind + 25% solar



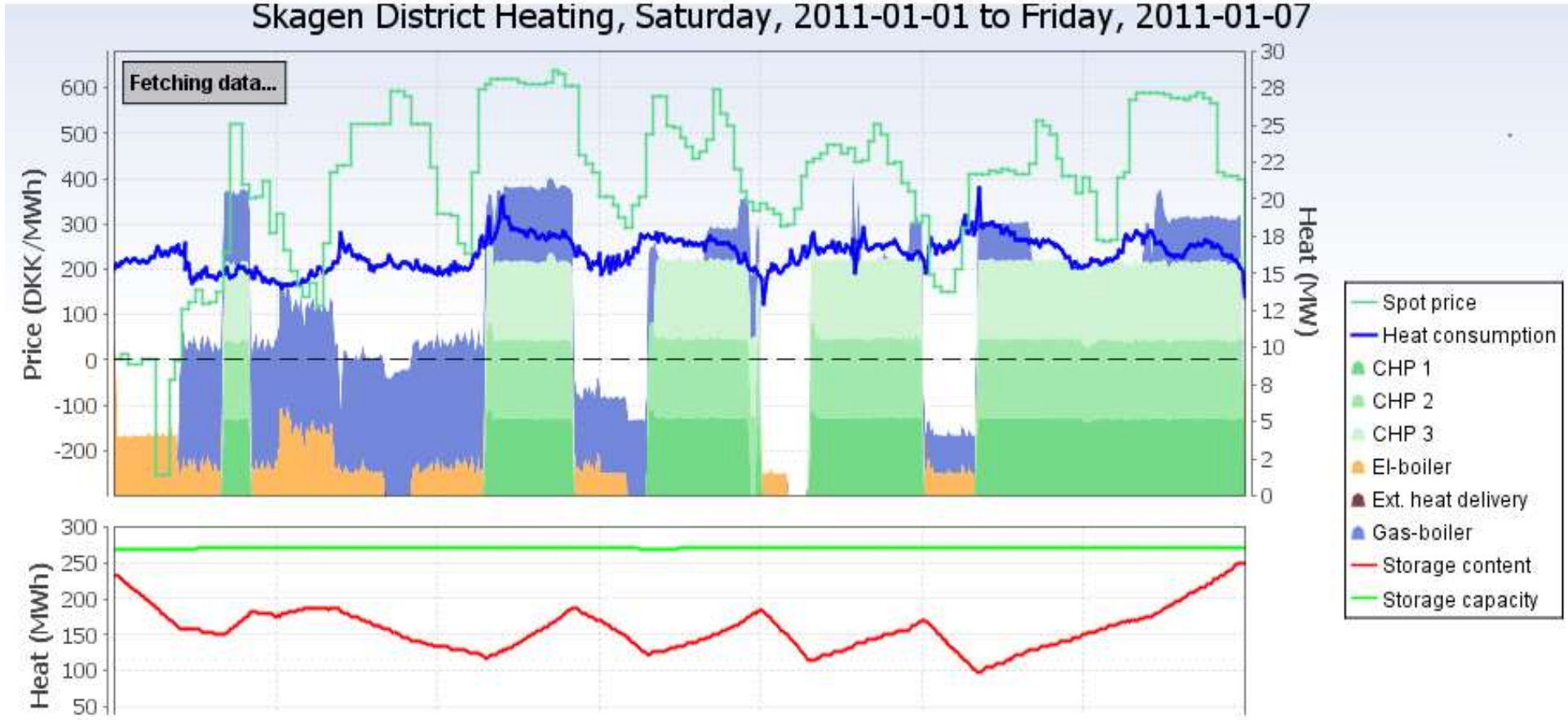
Electricity production in Germany in week 18 2016



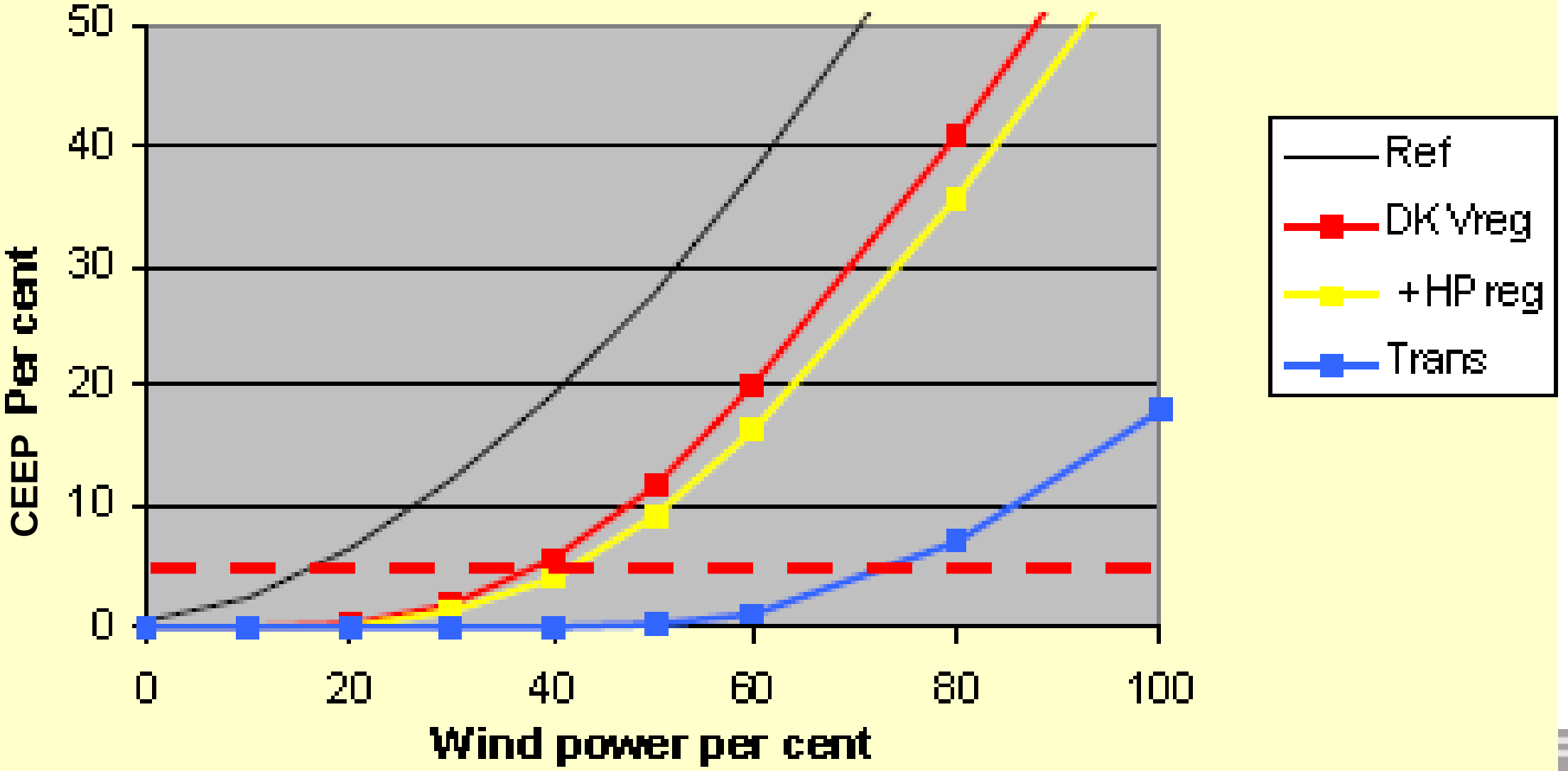
Demand response – power-to-X

- 20th century energy systems: supply follows demand
- 21st century energy systems: demand follows supply -> smart energy systems

Skagen CHP plant – power-to-heat



Surplus Electricity Production
Including grid-stbilisation



Flexibility options

- Flexible demand
- Flexible thermal power plants
- Power to heat with thermal storage
  - HP to DHC
  - Individual HP
- Smart charging + V2G
- Hydrogen + electrofuels production
- Energy storage (battery, PHS, molten salt storage, rock bed storage, CAES etc.)

Energy planning tools

- EnergyPlan
  - Made for power and heat integration
  - Heat storage is 2 orders of magnitude cheaper than electricity storage
  - 40% of final energy demand in Europe is for heating
  - One year – just simulation
- H2RES
  - Power and heat integration
  - Long term optimal addition of new capacities

Energy planning tools

- Plexos
  - Can model power and heat integration but is made for power modelling
  - Long term optimal addition of new capacities
- LEAP
  - Good for modelling demand developing, but not for supply integration
- MARCAL/TIMES
  - Good for modelling demand developing, but not for supply integration